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JUN 75 W C ROSE, G V HEISER  
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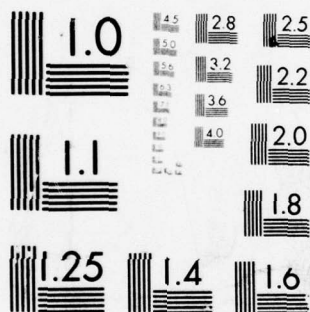
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SUMMARY REPORT

LO-MIX MAINTENANCE ENGINEERING ANALYSES  
(LMMEA)  
PILOT EFFORT

June 1975

Prepared for  
SURFACE SHIP MAINTENANCE PROJECT  
PMS-306  
NAVAL SEA SYSTEMS COMMAND  
WASHINGTON, D.C.  
under Contract N00123-73-C-1698

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strategy, a revised approach to establishing support requirements for systems, equipments, and components is required to meet acquisition time and cost constraints.

A technique has been developed that makes use of the technical documentation, historical data, and similarity comparisons of like components and provides the basis for reducing the estimated cost of developing logistics support requirements for systems, equipments, and components involved in the designated ships.

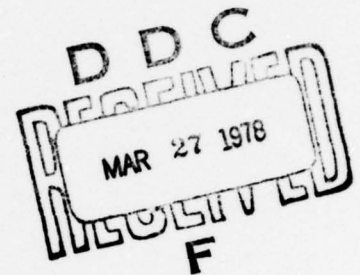
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LO-MIX MAINTENANCE ENGINEERING ANALYSES  
(LMMEA)  
PILOT EFFORT

June 1975



Prepared for  
Surface Ship Maintenance Project  
PMS-306  
Naval Sea Systems Command  
Washington, D.C.  
under Contract N00123-73-C-1698

by  
W.C. Rose  
G.V. Heiser

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## ABSTRACT

The CNO has imposed constraints on new ship projects in the areas of shipboard manning, ship displacement, and follow-ship costs. As a result of these constraints, it was necessary to develop new maintenance strategies that reduce Organization-level maintenance and emphasize Intermediate and Depot-level maintenance, rotatable-pool item replacement, and repair of repairables for the CNO-designated new-ship projects. These ships have been called LO-MIX ships.

In establishing a logistics support system to serve the new maintenance strategy, a revised approach to establishing support requirements for systems, equipments, and components is required to meet acquisition time and cost constraints.

A technique has been developed that makes use of the technical documentation, historical data, and similarity comparisons of like components and provides the basis for reducing the estimated cost of developing logistics support requirements for systems, equipments, and components involved in the designated ships.

This technique is called the LO-MIX Maintenance Engineering Analysis (LMMEA) technique. Preliminary verification of the technique has been completed by applications to selected units.



## SUMMARY

This report summarizes the work performed in developing and verifying, for equipment and components to be installed in LO-MIX ships, a Maintenance Engineering Analysis technique that would be less time-consuming to apply and more quickly productive of usable results than the method described in MIL-M-24365A.

The work was accomplished under two separate but related tasks. The first task resulted in the development of the required technique. The TRIDENT Logistics Data System was used as the data-processing system that would receive the results of the technique as input data elements and produce the total consolidated logistic-support-element package requirements for the two classes of ships. The report of this work is contained in ARINC Research Publication 1616-09-3-1341.

In the second task, the technique was applied, on a pilot-program basis, to verify its adequacy and the time estimates for application. During the performance of this second task, the use of the TRIDENT LDS was discontinued. This necessitated a revision of the application instructions and technique forms under a modification to the task and resulted in a reduction in the number of analyses made in the pilot program.

As a result of the reductions in the number of LMMEAs performed, further verification effort is considered warranted and is recommended.

The technique developed and evaluated is called the LO-MIX Maintenance Engineering Analysis (LMMEA) technique. The term LO-MIX applies to a new Navy ship manning and maintenance philosophy that deemphasizes maintenance at the Organization level and emphasizes module replacement at the Organization level, module and component replacement at an off-ship Intermediate level, and piece-part repair at the Intermediate and Depot levels.

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## CHAPTER ONE

### INTRODUCTION

#### 1.1 GENERAL

This report summarizes the work performed in developing and verifying, for equipment and components to be installed in LO-MIX ships, a Maintenance Engineering Analysis technique that would be less time-consuming to apply and more quickly productive of usable results than the method described in MIL-M-24365A. A basic concession made at the start of the work was that it would be acceptable to sacrifice some accuracy to achieve the objectives of reduced cost and performance time.

#### 1.2 OBJECTIVES

Although this report addresses specifically the effort involved in verifying the MEA technique developed earlier, it is appropriate here to identify the objectives of the total effort to place the verification task in the proper context.

##### 1.2.1 Basic Objective

The basic objective of the total effort was to identify and develop a technique for the rapid identification of logistics support elements, within the Navy ILS concept, necessary to support equipment and components to be installed in three designated ship classes of the LO-MIX ship category. The technique-development objective included the requirement to provide the data-element vehicle that would be the basis for using the TRIDENT Logistic Data System (TLDS) in consolidating and relating data-element inputs to produce complete logistics support requirements for the total LO-MIX ship population.

The technique developed has been called the LO-MIX Maintenance Engineering Analysis (LMMEA) technique. The term LO-MIX applies to a new Navy ship manning and maintenance philosophy that deemphasizes maintenance at the Organizational level and emphasizes module replacement at the Organizational level, module and component replacement at an off-ship Intermediate level, and piece-part replacement or repair at the Intermediate and Depot levels.

A secondary but vital objective was the preparation of detailed instructions and data forms which, when combined with a basic understanding of the LMMEA technique, could be used by the Navy or any of its agents in performing LMMEAs.

#### 1.2.2 Verification Objective

The objective of the verification effort was to demonstrate that the technique was sound and that the data elements required by the planned logistics system could be developed and entered properly on the forms provided. This demonstration was to be achieved by preparing LMMEAs for specified units, on a pilot-program basis, using the detailed instructions for direction and guidance.

#### 1.3 PERFORMANCE PERIODS

The total effort spanned the period 25 April 1974 through 30 June 1975. The basic technique development was accomplished under Task 9 of Contract N00123-73-C-1698 from 25 April 1974 through December 31 1974. The verification was performed under Task 12 of the same contract and extended from 1 January 1975 through 30 June 1975.

All work was conducted under the sponsorship of the Naval Sea Systems Command (NAVSEASYS COM), Code PMS 306.

#### 1.4 TECHNIQUE DEVELOPMENT

The LMMEA technique-development report and the initial version of the detailed Data Analysis Sheets and preparation instructions, which are used in the application of the technique and constitute the TLDS data element input vehicle, are provided in ARINC Research Publication 1616-09-3-1341 and support documents. Those portions of the technique development and application requirements reports necessary to an understanding of the technique and pertinent to the verification effort are discussed in Chapter Two. The complete report is presented in Appendix A.

#### 1.5 VERIFICATION

The results of the task effort to verify the adequacy of the technique and the detailed instructions designed to enable technicians to perform LMMEAs in the predicted time periods for the various LMMEA classes are presented in Chapter Three.

Shortly after the application and technique-verification effort was initiated, a decision was made by the project sponsor not to use the TRIDENT Logistic Data System as the data-processing system that would

make use of the data items resulting from the planned LMMEA program. This decision did not affect the basic technique, previously developed. It did affect the Data Analysis Sheets and the instructions for their preparation.

The requirement that the detailed instructions and the Data Analysis Sheets be revised within the funding resources and time schedule already established for the verification effort resulted in reducing the number of LMMEAs to be performed.

#### 1.6 LMMEA APPLICATION PROGRAM

The LO-MIX ship logistic support program initially visualized by PMS-306 required the development of logistics support requirements data for all equipment and components to be installed in the designated LO-MIX ships. The number of units for which an LMMEA would be required was estimated to be on the order of 3000, with results required within a period of three to four years.

#### 1.7 PLAN OF REPORT

The remaining chapters of this report provide the basis for understanding the fundamentals of the LMMEA technique (Chapter Two), summarize the verification and revision work effort (Chapter Three), and present conclusions and recommendations (Chapter Four).



## CHAPTER TWO

### LMMEA TECHNIQUE DEVELOPMENT

#### 2.1 BACKGROUND

##### 2.1.1 Project Establishment

In directing new ship projects -- including the Patrol Frigate (PF), Sea Control Ship (SCS), and Patrol Hydrofoil, guided Missile (PHM) -- the Chief of Naval Operations has imposed constraints in the areas of shipboard manning, ship displacement, and follow-ship cost. These constraints, in turn, have led the Ship Acquisition Project Managers (SHAPMs) for these programs to adopt a new maintenance strategy. The objectives of the new strategy for these ships are (1) to reduce Organization-level maintenance, thereby reducing the level of overall shipboard manning; and (2) to reduce the off-line time of the ships for depot maintenance, thereby increasing the utilization of the ships at sea.

The Chief of Naval Material (CNM) established Black Ball 4-72 on 20 September 1972, initially directing the effort to implement a maintenance and support program for the PF Class that is based on minimum maintenance aboard ship. Subsequently, the task was expanded to address all new future ship types having constraints of the nature noted above, and to develop a Program Management Plan for adequate maintenance and supply support of these new and future constrained ship types.

As a result of these requirements, the Advanced Logistic Support Project (PMS-306) was established on an interim basis by NAVSHIPS NOTE 5430 of 18 December 1973.

In January 1975, the Advanced Logistic Support Project was reconstituted under the project title Surface Ship Maintenance Project (PMS-306). Concepts addressing new maintenance strategies previously identified with the three ship classes cited above were extended to all maintenance-limited ships.

##### 2.1.2 Project Requirements

As stated in NAVSEA INST. 5400.11, the constraints imposed on manning, ship displacement, and follow-ship cost of new and future ship types -- along with plans for using these ships that call for increasing their

time between modernizations -- require maintenance and supply strategies new to the surface forces. These strategies will require a modification to the current maintenance philosophy, from maximum maintenance at the Organization-level to greater dependence on off-ships maintenance and supply support systems. These alterations can be classified in the following major categories:

- Shifting to the Intermediate and Depot levels of maintenance a substantial portion of Organization-level maintenance
- Expanding the modular-replacement method of repair
- Acquiring systems and resources for the progressive overhaul of ships between major modernizations
- Modifying management procedures to facilitate the above maintenance and supply-strategy alterations

#### 2.1.3 Project Responsibilities

The responsibilities of PMS 306 are specified in NAVSEA INST 5400.11 of 15 January 1975; they include the following:

- Develop, implement, and direct alterations to the current Navy maintenance and supply system and modify the management procedures commensurate with these alterations to assure an adequate, integrated maintenance and supply system to accommodate the fleet introduction of the new maintenance-limited surface ships such as the PF, SCS, and PHM
- Develop an integrated ship maintenance strategy that may be used in support of other surface ships in addition to the maintenance-limited ship introductions
- Develop an expanded intermediate maintenance capability/capacity to accommodate projected increases in the requirement for Intermediate-level maintenance support, both ashore and afloat

#### 2.1.4 Project Implementation

In implementing the project effort, it was determined by PMS-306 that an extensive Maintenance Engineering Analysis effort, addressing systems, equipment, and components incorporated in the designated ship classes, would be required to establish the foundation for logistics support planning in the context of the PMS-306 assigned responsibilities. It was also recognized that time and funding limitations were such that the MEA effort under MIL-M-24365A could not be accommodated. Accordingly, PMS-306, in early 1974, initiated an effort to develop an alternate technique for developing logistics support requirements that would be less time-consuming and at the same time produce the desired results.



## 2.2 LMMEA TECHNIQUE DEVELOPMENT

### 2.2.1 Task Assignment

Under Contract N00123-73-C-1698, Task 9, ARINC Research Corporation was tasked to investigate an alternate technique to that of MIL-M-24365A and to develop a technique that would provide the desired results in the time period specified and at an acceptable cost.

### 2.2.2 Technique Development

The development of the LMMEA technique is described in ARINC Research Publication 1616-09-3-1341 (Appendix A). The technique is based on the fundamental assumption that similar systems, equipments, or components will evidence similar logistics support requirements and that such requirements can be extrapolated or interpolated from known data to identify requirements for similar units for which data are not specifically available.

In addition, it was recognized that extensive data, including MEAs performed previously under MIL-M-24365A, would be available. The technique, as developed, identified data cases and LMMEA classes, as shown in Figure 1 and Table 1. Historical Data, as used in Figure 1 were defined as available data describing the maintenance history, supply support demands, facility requirements, and other information addressing usage and maintenance experience for a particular item of equipment.

	Historical Data Available	Historical Data Not Available
MEA Available	Case I	Case II
MEA Not Available	Case III	Case IV

Figure 1. MEA/HISTORICAL DATA MATRIX

Table 1. RELATIONSHIP OF DATA-AVAILABILITY CASES AND LMMEA CLASSES			
Data Availability	LMMEA Classes by Equipment Groups		
	Under Development and Testing	Lead Component	Follow-On Components
Case I	N/A	Class II	Class III
Case II	N/A	Class II	Class III
Case III	N/A	Class II	Class III
Case IV	Class I	N/A	Class III

On the basis of the data-availability cases, three classes of LMMEA were identified. These three LMMEA classes are related to the data cases as shown in Table 1.

In all cases, complete technical documentation for units already delivered to the Navy and in use, or design specifications describing those units which have not been delivered, is also assumed to be available.

A unique characteristic of the LMMEA technique is the requirement that module candidates, consisting of subassemblies of a particular unit, be identified during the analysis. The LMMEA Performance Instructions (Appendix B) contain a decision diagram and criteria for such identification.

#### 2.2.3 Resource Requirements

For most effective use of the LMMEA technique, personnel knowledgeable in the operation and maintenance of the various kinds of units involved in the effort should be assigned. On the basis of such assignment, it was estimated that the time periods for performance of various classes of LMMEA would be as follows:

Class I (New Unit): 3 Man-Months

Class II (Lead Unit): 3 Man-Weeks

Class III (Follow Units): 3 Man-Days

These periods do not include accumulation of the requisite technical documentation and the available historical data upon which each LMMEA will be based.

#### 2.2.4 Technique Application

In the application of the LMMEA technique to large numbers of equipment and components, action should proceed in the following sequence:

- Identify all units for which an LMMEA is to be performed. This is best accomplished by developing a top-down breakdown of all designated systems in a given ship class to the lowest level of each system that, as a unit, contributes or can be expected to contribute to the maintenance burden of the ship class.
- Group all equipment by generic type, in accordance with the LMMEA technique (Appendix A, paragraph 5.3.2).
- Acquire all available technical documentation (Technical Manuals, APLs, plans, specifications, and historical data) available for each unit.
- Identify all Class I LMMEA candidates (Appendix A, paragraph 5.3.3).

- Select lead-unit Class II LMMEA candidates for each group established (Appendix A, paragraph 5.3.3).
- Schedule the performance of Class II and lead-component Class I LMMEAs so that the lead component for each group is scheduled during the initial effort.
- Perform LMMEAs in accordance with LMMEA instructions (Appendix B).



## CHAPTER THREE

### LMMEA PILOT EFFORT

#### 3.1 GENERAL

The initial plan for the LMMEA pilot effort required the performance of three basic subtasks during the period 1 January 1975 through 30 June 1975 under Task 12 of Contract N00123-73-C-1698:

- Equipment Grouping. Group all FFG and PHM equipments in accordance with the LMMEA technique based on a government-furnished top-down breakdown of the ship systems.
- Scheduling. Schedule approximately 40 selected LMMEAs so that a representative sample of the various LMMEA classes can be obtained.
- LMMEA Performance. Perform LMMEAs on the selected equipment, in accordance with the LMMEA performance instructions. Keep records of time required in performing each LMMEA. Define or revise, as necessary, the LMMEA performance instruction as experience with its application is gained.

#### 3.2 TASK PERFORMANCE

##### 3.2.1 Initial Task Delay

Because of delays in receipt of the top-down breakdowns of ship systems in the FFG and PHM, grouping of equipment and scheduling of LMMEAs in accordance with the task plan could not be accomplished. As an alternate, work proceeded in conformance with interim direction of PMS-306, and the performance of six Class II LMMEAs was initiated. Concurrently, efforts were continued to obtain the requisite top-down breakdown of FFG and PHM ship systems.

##### 3.2.2 TRIDENT LDS Discontinued

During March, information was received by ARINC Research Corporation that, because of problems with the TRIDENT LDS, a decision had been made by PMS-306 not to use it as the data-processing system for the LO-MIX ship logistics support requirements. This decision had a significant impact on the LMMEA preparation instructions and the related Data Analysis Sheets,

which were designed to interface with the data-input requirements of the TRIDENT system. As a result, interim work continued in the preparation of LMMEAs designated by PMS-306 and a task modification was developed that reoriented the task effort to accommodate the new situation. This reorientation consisted of the following basic changes:

- Reduction in the number of LMMEAs
- Revision of the Data Analysis and the LMMEA preparation instructions to reflect the discontinuation of the TRIDENT LDS use

### 3.2.3 Task Completion

On the basis of the revised task, work proceeded in the performance of LMMEAs and in the revision of the Data Analysis Sheets and the LMMEA preparation instructions. A total of 18 Class II and 4 Class III LMMEAs were delivered. The performance times for both the Class II and Class III LMMEAs fall within the time requirements estimated in the technique development report.

No Class I LMMEAs were performed in this task since adequate documentation necessary to their performance could not be obtained in sufficient time to permit completion within the task performance period.

After the use of the TRIDENT LDS was discontinued, the Data Analysis Sheets were revised progressively by PMS-306 and ARINC Research Corporation. Consequently, LMMEAs performed during the early part of the task period were submitted on DAS forms that differ in some data elements. In addition, as experience was gained in the performance of LMMEAs, minor changes were found to be necessary, and these were incorporated in the DAS forms and reflected in the preparation instructions.

### 3.2.4 Deliverables

Task deliverables are listed in chronological order of their delivery in Appendix C to this report. In summary, delivered items consist of the following:

- Component group lists for FFG and PHM
- Pilot LMMEA schedule
- Data Analysis Sheets
- LMMEA preparation instructions
- Completed LMMEAs

## CHAPTER FOUR

### CONCLUSIONS AND RECOMMENDATIONS

#### 4.1 VERIFICATION

The decision to discontinue the planned use of the TRIDENT LDS and the resulting requirement that the Data Analysis Sheets and the LMMEA preparation instructions be revised had a serious impact on the LMMEA technique-verification effort. Because of time and funding constraints, it was necessary to reduce the number of LMMEAs to be performed under that effort. Although 22 LMMEAs were performed, the preponderance of Class II LMMEAs compromised verification action with regard to Class I and Class III LMMEAs. The number of LMMEAs performed under the pilot effort does not adequately verify the LMMEA technique as the basis for a comprehensive program on which the LO-MIX Logistic Support System is to be based. The time estimates for accomplishing the Class II LMMEA are considered reasonable.

It is recommended that further verification effort be completed before a full-scale LMMEA effort is undertaken.

#### 4.2 GENERAL DOCUMENTATION

It became evident early in the effort that the accumulation of documentation necessary to the proper performance of LMMEAs required more time than had been anticipated. In any program requiring extensive documentation, special effort is necessary to accumulate this documentation in advance of full-scale production. Although acquisition of documentation for LMMEAs not yet in progress can proceed concurrently with other LMMEA efforts, careful scheduling and follow-up of documentation receipt is essential to a successful, uninterrupted effort.

It is recommended that the schedule for a large-scale LMMEA program include at least three months' lead time for the acquisition of existing documentation before the schedule requires performance of any specific LMMEA. It is further recommended that particular attention be paid to the acquisition of procedural and usage documentation such as that involved in the preventive maintenance system and represented by APLs.



#### 4.3 SPECIAL DOCUMENTATION

Where particular documentation, such as an APL, does not exist for a particular item, the LMMEA can serve as the initial source of data for preparation of an APL. Conversely, an existing APL can serve as an audit of the adequacy of parts and subassembly requirements identified as required by the LMMEA. The same analogy can be drawn for planned maintenance requirements, as shown on MRC cards, if they exist in approved PMS documentation. If they do not exist, the LMMEA can serve as the source for PMS documentation at the Organization level.

It is recommended that particular attention be paid to the acquisition of existing APLs and PMS documentation addressing all items of equipment involved in the program.

#### 4.4 ANALYST QUALIFICATION

The rapidity of LMMEA completion is a function of the analyst's knowledge of the kind of equipment he is analyzing and the completeness of the basic documentation he has at his disposal. This is particularly true in the development of the required Failure Mode Maintenance Requirements Analysis for each unit. Technicians or engineers assigned to perform LMMEAs must be familiar with the equipment with which they are working.

It is recommended that any specifications prepared for the LMMEA program effort include the requirement that personnel familiar with the system, equipments, and components to be analyzed be available and perform LMMEAs that involve items within their knowledge and experience.

#### 4.5 RELIABILITY FACTORS

Reliability factors used in performing an LMMEA are not always available and in many cases must be developed by association with similar items of equipment. This situation introduces a greater potential for error than any of the other element entries in the Data Analysis Sheets. The best source of reliability factors available proved to be the data bank maintained by NAVSEC.

It is recommended that the NAVSEC Reliability, Maintainability, and Availability Design Data Bank be expanded and updated, particularly in the areas of equipment to be installed in LO-MIX ships.

**APPENDIX A**

**Reproduction of ARINC Research Publication 1616-09-3-1341:**

**LO-MIX MAINTENANCE ENGINEERING ANALYSIS TECHNIQUE**

**(See file copy)**

APPENDIX B

Reproduction of ARINC Research Publication 1616-12-4-1393:

LO-MIX MAINTENANCE ENGINEERING ANALYSIS (LMMEA)  
INSTRUCTIONS AND FORMS

(See file copy)



# APPENDIX C

## LISTING OF CONTRACT DELIVERABLES

Item	How Submitted	Submittal Date
Completed LMMEAs (6 Class II)	Letter CA/E-75-186	3/25/75
LMMEA Schedule of Application	Letter CA/E-75-281	4/1/75
Completed Equipment Groups	Letter CA/E-75-276	4/2/75
Completed LMMEAs (4 Class II)	Letter CA/E-75-291	4/7/75
LMMEA DAS Forms (Preliminary Design)	Letter CA/E-75-280	4/12/75
LMMEA DAS Forms (Final Design)	Letter CA/E-75-329	5/29/75
Completed LMMEAs (3 Class II, 2 Class III)	Letter CA/E-75-306	4/30/75
LMMEA DAS Instructions and Forms (Preliminary Draft)	Letter CA/E-75-305	4/30/75
Completed LMMEAs (3 Class II)	Letter CA/E-75-343	5/30/75
Completed LMMEAs (4 Class II)	Letter CA/E-75-411	6/30/75
LMMEA DAS Instructions and Forms (Final Draft)	Letter CA/E-75-412	6/30/75
Final Draft	Letter CA/E-75-413	6/30/75